ATMOSPHERIC PHYSICS

Corrections and Additions for the HITRAN Water Vapor Spectroscopic Database

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Systematic errors have been found and corrected in the HITRAN (High-Resolution Transmission Molecular Absorption Database) water vapor line absorption intensities in the visible and near-infrared spectral regions. The HITRAN database has been used extensively in the calculation of atmospheric absorption of solar radiation. The most important corrections found were a 14.4% increase of the intensity of the 940-nanometer (nm) band and an 8.7% increase of the intensity of the 820-nm band. These systematic errors in the HITRAN tabulations were due to errors in the unit conversion from the measurements published in centimeter/(centimeter atmosphere) (cm^{-1}/(cm-atm)) to the HITRAN common units cm^{-1}/(molecule/cm^2). Because the absorption of water vapor in these important regions is greater than has been used in model calculations for the Earth's atmospheric absorption, there is a diminished necessity for an hypothesized "continuum absorption" in the atmosphere.

These corrections have been applied to the HITRAN water vapor line list above 8000 cm^{-1} and have been submitted to HITRAN for posting on its website update page. In addition, measurements and assignments of some weak water vapor lines in this region (not included in the HITRAN list) have been reported.

Prasad Varanasi (State University of New York at Stony Brook) and Richard S. Freedman (SPRI) collaborated in this research.

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How Effectively Can Freeze-Drying by Optically Thin, Laminar Cirrus Dehydrate Air Rising Slowly Across the Tropical Tropopause

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Over the past 20 years, many theories have been proposed to explain the extreme dryness of air in the tropical lower stratosphere. Recent observations suggest that the flux of air into the stratosphere may be dominated by slow ascent across the tropopause throughout much of the tropics. In this study, cloud model simulations were used to show that laminar, optically thin cirrus clouds (frequently observed near the tropopause) can effectively freeze-dry air entering the tropical stratosphere. A detailed ice cloud microphysical model coupled to a large-eddy simulation dynamical model was used for these simulations. As shown in the top panel of the figure, if no cloud forms, the slow ascent across the tropopause will eventually increase the water vapor mixing ratio above 5 parts per million by volume (ppmv). These values are much higher than observed water vapor mixing ratios. However, if we include cloud formation, then the slow ascent drives adiabatic cooling and nucleation of a small number of ice crystals (<10/liter). These crystals grow rapidly and precipitate out within a few hours. The ice crystal nucleation and growth prevents the relative humidity (with respect to ice) from rising above the threshold of ice nucleation (130–160%) and limits the water vapor mixing ratio above the tropopause to 3–4 ppmv (bottom panel of figure). The nucleation threshold depends upon the aerosol composition in the tropopause region, which is not well known. Simulations including gravity waves propagating through the model were also done. Temperature oscillations driven by the waves drive nucleation of larger ice number densities and more complete dehydration of the rising air. These conditions promote the effectiveness of upper tropospheric aerosols as ice nuclei and the climatology of waves in the tropopause region. In situ tropical humidity observations from several field experiments have been gathered. These measurements included accurate water vapor sensors mounted on the NASA ER-2 as well as balloon-borne instruments. The humidity observations provide a few

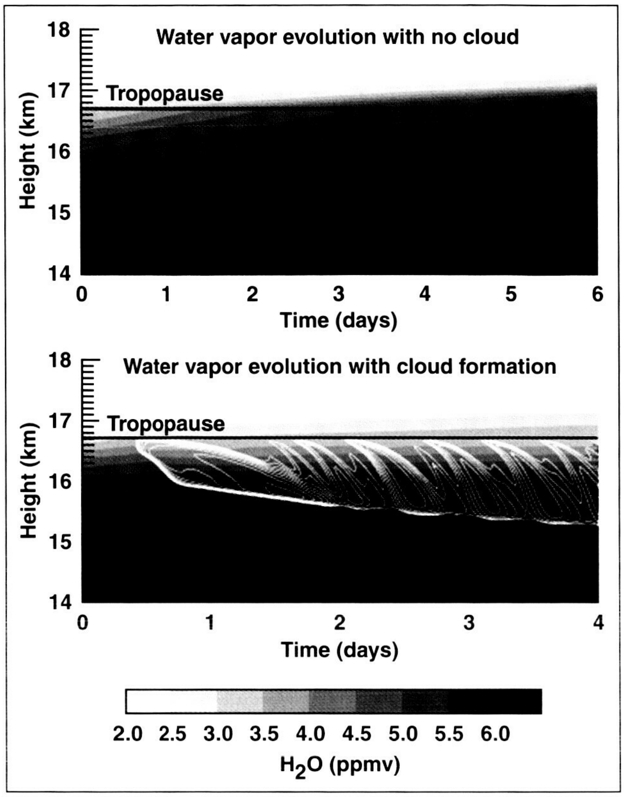

Fig. 1. Contours of water vapor mixing ratio (shading) are plotted versus time and height. The top panel shows that if no cloud forms, ascending air transports excessive amounts of water across the tropopause into the stratosphere. The bottom panel shows the dehydration of rising air if cloud formation is included in the model. The white contours show the cloud ice water content.

examples of supersaturated air near the tropopause (as predicted by the model); however, further observations of water vapor and wave motions near the tropical tropopause are required to clarify the cloud formation and dehydration process.

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Lofting of Soot Particles into the Middle Atmosphere by Gravito-Photophoresis

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The observed existence of soot aerosol at 20-kilometer (km) altitude (which arguably is generated by aircraft flying in corridors at 10–12 km) requires a transport mechanism in a thermally stable stratosphere that is different from isentropic or dynamic mixing. Such a mechanism could be provided by gravito-photophoresis, induced by the incidence of sunlight on strongly absorbing fractal soot particles. This particle absorptivity, in conjunction with uneven surface-coating of sulfuric acid and their fractal nature, makes soot particles (with maximum dimensions approaching 1 micrometer) particularly conducive to gravito-photophoresis. It is the requirement of a restoring torque that orients the particle with respect to gravity. This required force is provided by the fractal characteristics of soot, and a body-fixed photophoretic force is given by asymmetric thermal accommodation coefficients across the uneven surface of the particle.

During the Subsonic Assessment (SASS) Ozone and Nitrogen Oxides Experiment (SONEX) field campaign in 1997, soot aerosol was sampled in commercial airline flight corridors over the northeastern Atlantic, and the gravitational and gravito-photophoretic forces acting on those soot particles were computed. The result is that 16% by number, corresponding to 51% by mass, of a soot particle size distribution could be lofted against gravity by gravito-photophoresis. The calculated vertical velocities, exceeding settling velocities by up to a factor of 30, suggest that it takes about 30 years to transport soot from 10 to 20 km and 20 years to transport soot from 20 to 80 km. On the basis of current stratospheric soot loading, the resulting soot mass flux at 20-km altitude is 5e-18 grams per square centimeter per second (g cm^{-2} sec^{-1}), which is within one order of magnitude of the influx of meteoritic dust into the mesosphere from outer space.

The effect of gravito-photophoresis is strongly altitude dependent. With increasing pressure near the Earth's surface, the lofting force falls off quickly. Above the mesopause, the lofting force becomes smaller because of a dominating energy loss by